CRYOGENIC SYSTEM (WBS 1.3)

i. Introduction

The basic function of the RHIC Cryogenic System is to maintain the superconducting magnets and the superconducting bus connecting them in the two rings of the collider at or below their design operating temperature.

The performance specifications, which have a major influence on the design of the cryogenic system, include the following points:

1. All magnets must be maintained below their nominal operating temperature of 4.6 K during steady-state operations.
2. Each sextant of each ring can be isolated for independent warmup and cooldown for repairs if required. During the time required for this procedure the balance of the sextants in the affected ring will not be warmed, but may drift up in temperature.
3. In order to permit system design calculations to investigate "off-design" operations and to size system components, the worst case design heat load is for double the nominal heat load of all magnets in one sextant. Under these conditions, the warmest magnet temperature must still be less than 4.6 K.
4. Reliability of the cryogenic system shall be such that its availability (at nominal design load conditions) is greater than 90%.

The design of the cryogenic system focused on satisfying these requirements while also considering many non-performance constraints, historical and geographical, which must also be factored into the design of the system. The design which has evolved is presented below.

The main feature of the RHIC Cryogenic System (shown schematically in Fig. 3-1) is the helium refrigerator. This refrigerator was fabricated, installed and, after testing, was accepted by BNL in March 1986. The refrigerator was designed to match the load of the CBA Project with a primary capacity of 24.8 kW at about 3.8 K and a secondary, higher temperature capacity of 55 kW at about 55 K. This refrigerator with its matching room temperature compressor system is used to produce the refrigeration required for RHIC.

Cold centrifugal compressors are used to circulate single-phase, supercritical pressure helium in a closed loop through the magnets of each ring and a distributed network of heat exchangers (called recoolers). This is shown schematically in Fig. 3-2. Heat is removed from the circulating helium stream by heat exchange with a boiling liquid helium bath in the recoolers. This type of system is chosen so that the mass of helium in the magnet cooling system can be maintained nearly constant during excursions in temperature due to quenches or other upsets. The pressure in the magnet side of the system is allowed to rise (within predetermined limits) without venting of cold helium. Retaining the helium in the magnets ensures that the refrigeration required to recover from such an event will be minimized and that the refrigerator operation will not be upset by the receipt of excessive amounts of cold helium gas generated by the expansion of the warmed helium in the load. Cold gas from the refrigerator is added to the closed loop of each ring as required to replace the gas removed from the stream to cool the magnet electric power leads.

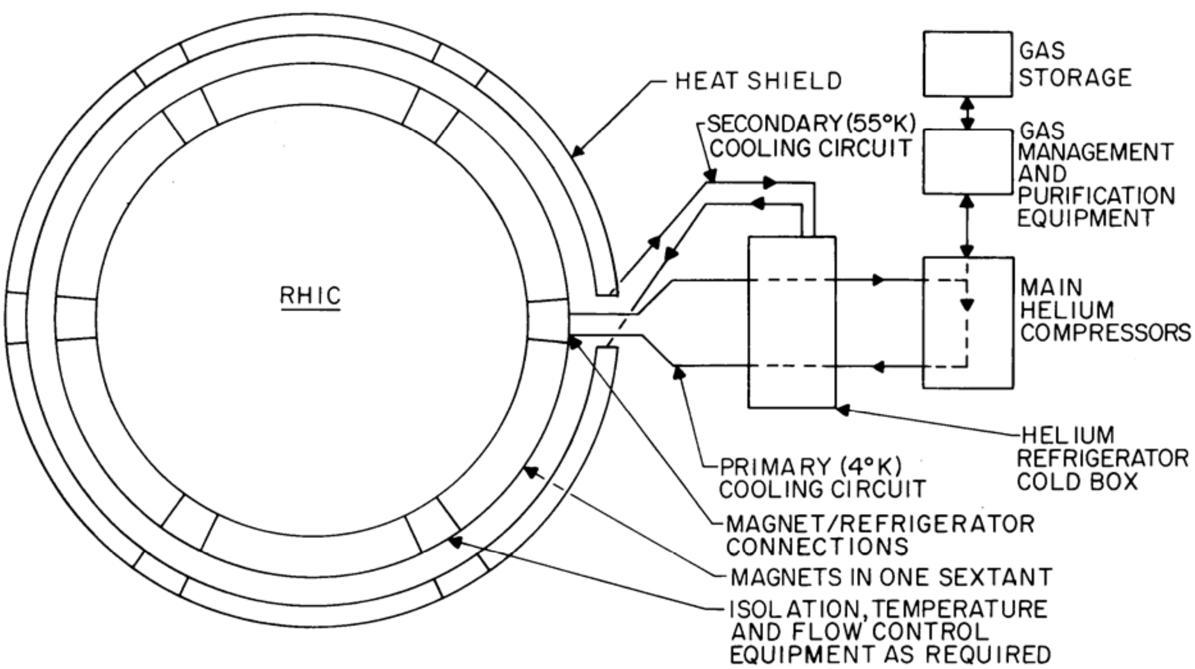

Fig. 3-1. Simplified drawing of RHIC Cryogenic System. Only one of the rings is shown. The second is in parallel with the first.

Connecting the refrigerator and the load is a network of vacuum-jacketed piping. Piping is also required to carry the helium wherever there are long gaps in the magnets in the ring, e.g., across the experimental areas.

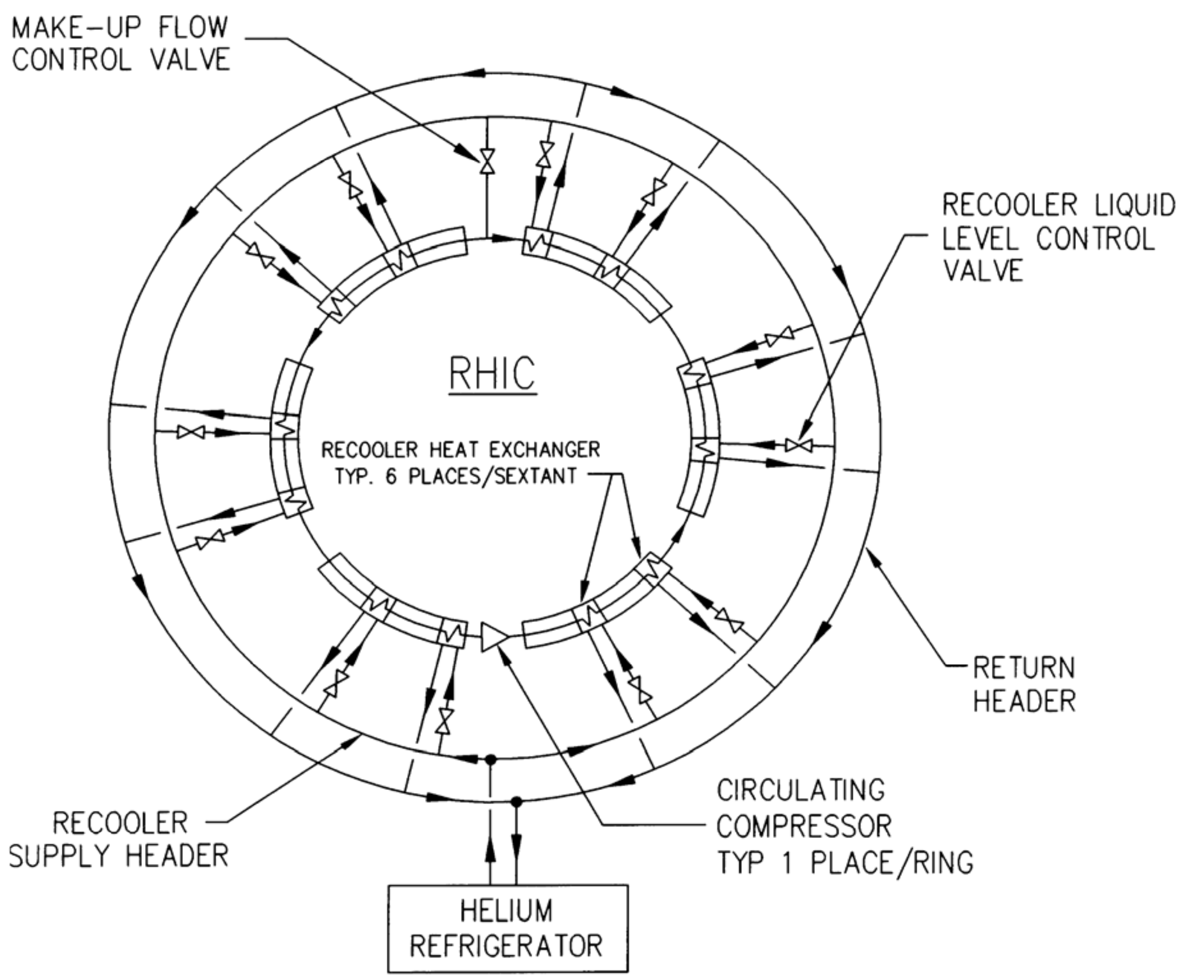

Fig. 3-2. Helium primary flow circuit for steady-state operation.
Only one of the rings is shown.